

## PATENT ABSTRACTS OF JAPAN

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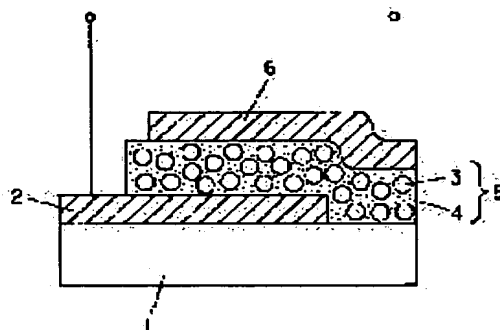
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## (54) THIN FILM CAPACITOR AND ITS MANUFACTURE

## (57)Abstract:

**PURPOSE:** To provide a method of manufacturing a thin film capacitor of excellent insulating properties at a specific temperature or lower and a CR circuit device provided with the thin film capacitor and high in accuracy and reliability.

**CONSTITUTION:** A thin film capacitor is composed of a PC (polycarbonate) printed board 1, a lower aluminum electrode 2, a dielectric film 5 composed of composite perovskite oxide powder 3 and hardening resin 4, and an upper aluminum electrode. Composite perovskite oxide powder 3 of permittivity a few thousands or above is dispersed into volatile solvent which contains hardening resin 4, the disperse system is applied onto the PC printed board 1 through a spin coating method, the printed board 1 is heated at a temperature of 80° C and dried out by removing the volatile solvent by heating, and the hardening resin contained in the solvent is hardened by irradiation with ultraviolet rays to form a dielectric film 5 at a temperature of 150° C or below.



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CLAIMS

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## [Claim(s)]

[Claim 1] The thin film capacitor which is a thin film capacitor which prepared the dielectric film between the lower electrode and the up electrode, and carries out the description of having used the mixture of compound perovskite oxide and hardenability resin as a dielectric film.

[Claim 2] The thin film capacitor according to claim 1 which uses a compound perovskite oxide as powder and is characterized by the particle size of the powder being 0.4 micrometers - 1.4 micrometers.

[Claim 3] The thin film capacitor according to claim 1 which uses a compound perovskite oxide as powder and is characterized by the addition of the hardenability resin to the powder being 0.5vol(s)% - 7vol%.

[Claim 4] The thin film capacitor according to claim 1 characterized by using ultraviolet-rays hardening resin as hardenability resin.

[Claim 5] For the principal component of a compound perovskite oxide, an empirical formula is  $ABO_3$ . Thin film capacitor according to claim 1 characterized by being expressed, containing at least one sort of Pb, Sr, Ba, and La as A, and containing at least one sort of Ti, Zr, Ta, Mg, and Nb as B.

[Claim 6] The manufacture approach of the thin film capacitor characterized by having formed the lower electrode on the substrate, having prepared the mixture of compound perovskite oxide powder and hardenability resin on said lower electrode, having stiffened said hardening resin at the temperature of 150 degrees C or less after that, having formed the dielectric film, and forming an up electrode on said dielectric film.

[Claim 7] The manufacture approach of the thin film capacitor according to claim 6 which uses hardenability resin as ultraviolet-rays hardening resin, and is characterized by irradiating ultraviolet rays and forming a dielectric film.

[Claim 8] CR circuit element which is a CR circuit element which combined resistance and a capacitor electrically, and is characterized by using a thin film capacitor according to claim 1 as a capacitor.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the thin film capacitor widely used for a public welfare device etc., and its manufacture approach.

[0002]

[Description of the Prior Art] When forming a thin film capacitor on the printed circuit board made of resin, the cure against heat at the time of the dielectric membrane formation process of having taken into consideration the heat-resistant temperature of a resin substrate is an important technical problem. As a conventional technique, it is SiO<sub>2</sub> by electron cyclotron resonance vapor growth (ECR-CVD method). The approach of forming the thin film capacitor using the film on a glass epoxy group plate with a heat-resistant temperature of 200 degrees C is announced by the 126th page from the 123rd page (1993) of the 5th microelectronics symposium collected works.

[0003]

[Problem(s) to be Solved by the Invention] SiO<sub>2</sub> formed with the ECR-CVD method The capacity consistencies of a dielectric film capacitor are 13.1 nF/cm<sup>2</sup>. Although the property of practical use level is acquired, considering cost performance, the capacity consistency of 5 times or more is required. In order to attain one 5 times the capacity consistency of this, dielectric thickness had to be set to one fifth of 60nm, and there was a problem on which insulation deteriorates.

[0004] This invention solves said conventional technical problem, and is 70 nF/cm<sup>2</sup>. While aiming at offering the thin film capacitor which has the above capacity consistency and was excellent in insulation, and its manufacture approach, it aims at offering CR circuit element of high degree of accuracy and high-reliability using it.

[0005]

[Means for Solving the Problem] In order to attain this object, particle size fabricated the compound perovskite oxide powder which is 0.4 micrometers - 1.4 micrometers using 0.5vol(s)% - 7vol% hardenability resin as a dielectric film.

[0006]

[Function] The dielectric film which uses as a principal component the compound perovskite oxide with which a dielectric constant has thousands or more and is used for a ceramic condenser by the aforementioned means can be formed at the low temperature of 150 degrees C. Hardenability resin is used in order to bind compound perovskite oxide powder, but since the effective dielectric constant of a dielectric film will fall if the volume fraction of hardenability resin increases, 0.5vol% - 7vol% is the optimal. The particle size of compound perovskite oxide acts on a binding property and electric insulation. In 0.4 micrometers or less, surface area becomes large, and it becomes impossible for particle size to fully bind by 7vol% hardenability resin. Moreover, the opening between the grains with which particle size is set to 1.4 micrometers or more becomes large, and electric insulation deteriorates. Therefore, there is an operation which prevents decline in a dielectric constant and electric insulating degradation by setting particle size to 0.4 micrometers - 1.4 micrometers.

[0007]

[Example] Drawing 1 is the sectional view showing the structure of the thin film capacitor in one example of this invention, and a thin film capacitor consists of the dielectric film 5 and the aluminum up electrode 6 which consist of the polycarbonate (it omits Following PC) substrate 1 which is a printed circuit board made of resin, the aluminum lower electrode 2, compound perovskite oxide powder 3, and hardenability resin 4.

[0008] How to manufacture the thin film capacitor of this example is explained. After carrying out cleaning processing of dimension 50mmx50mmx2mm PC board 1, the aluminum film with a thickness of 1 micrometer was formed with vacuum evaporation technique, aluminum was etched by the photoresist method, and the aluminum lower electrode 2 was formed.

[0009] Next, Pb(Mg<sup>1</sup> / 3 Nb 2/3) O<sub>3</sub> compounded by the complex polymerization method The spin coat of the solvent which made the ultraviolet-rays hardening resin solvent which uses epoxy acrylate as a principal component distribute compound (PMN) perovskite oxide powder was carried out on PC board 1, and resin hardening by desiccation processing and an ultraviolet radiation exposure of a volatile solvent was performed. The dielectric film 5 which carries out etching clearance of the contact part of the aluminum lower electrode 2 by the photoresist method, and consists of compound perovskite oxide powder 3 and hardenability resin 4 was formed.

[0010] The thickness of the formed dielectric film 5 is 5 micrometers, and repeated and produced a spin coat, desiccation, and resin hardening. At the temperature of 80 degrees C, desiccation processing of a volatile solvent is

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time amount 30 minutes, and UV irradiation is amount of energy 65 KJ/m<sup>2</sup>. The deed temperature rise was suppressed at 150 degrees C or less for time amount 1 minute.

[0011] The volume fraction of the hardenability resin 4 after resin hardening produced the 0.1vol% - 10vol% thing depending on the concentration of the ultraviolet-rays hardening resin material in a solvent. On the dielectric film 5, 1 micrometer of aluminum film was formed with vacuum evaporation technique, it fabricated by the photoresist method, and the aluminum up electrode 6 was formed. The effective area of a thin film capacitor was decided by the part with which the aluminum up electrode 6 and the aluminum lower electrode 2 lapped, and was set to 3mmx2mm by this example.

[0012] A capacity consistency is so large that the capacity consistency of the produced thin film capacitor has a small volume fraction depending on the volume fraction of the hardenability resin 4 in a dielectric film 5. They are 70 nF/cm<sup>2</sup> so that drawing 10 may show. In order to obtain the above capacity consistency, the volume fraction of hardenability resin 4 needs to be less than [ 7vol% ]. However, when the volume fraction became less than [ 0.5vol% ], the binding operation of the PMN powder of hardenability resin 4 became weak, and exfoliation of a dielectric film 5 and decomposition arose.

[0013] Therefore, as for the volume fraction of the hardenability resin 4 in a dielectric film 5, it is desirable that it is 0.5vol(s)% - 7vol%. The particle size of PMN powder also influenced the mechanical strength and dielectric characteristics of a dielectric film 5. Since powdered surface area would increase if particle size is set to 0.4 micrometers or less, by the hardenability resin 4 which is 7vol%, the binding operation was weak, the crack arose in the dielectric film 5 and the short circuit was caused electrically. On the other hand, when the particle size of PMN was set to 1.4 micrometers or more, the irregularity of a dielectric film 5 became large and dielectric breakdown voltage deteriorated remarkably. Therefore, as for the particle size of the compound perovskite oxide powder 3, it is desirable that it is 0.4 micrometers - 1.4 micrometers.

[0014] As a compound perovskite oxide, they are TiO(Ba<sub>0.7</sub> Sr<sub>0.3</sub>)<sub>3</sub> (BST), Ba(Mg<sub>1/3</sub> Ta<sub>2/3</sub>)O<sub>3</sub> (BMT), and BaTiO<sub>3</sub> besides PMN (PLZT (Zr(Pb<sub>0.9</sub> La<sub>0.1</sub>)<sub>0.65</sub>Ti<sub>0.35</sub>)). (BT) and SrTiO<sub>3</sub> Similarly (ST) was compounded by the complex polymerization method.

[0015] The synthetic approach of PLZT powder is explained as an example. First, titanium tetra-isopropoxide (Ti<sub>4</sub> (C<sub>3</sub>H<sub>7</sub>O)) was dissolved in ethylene glycol / citric-acid solution, and then a zirconium nitrate (Zr(NO<sub>3</sub>)<sub>2</sub> and H<sub>2</sub>O), lead acetate (Pb(CH<sub>3</sub>COO)<sub>2</sub> and 3H<sub>2</sub>O), and an acetic-acid lanthanum (La(CH<sub>3</sub>COO)<sub>3</sub> and 1.5H<sub>2</sub>O) were dissolved. Heating concentration of this solution was carried out, the polyesterification reaction was advanced, and polymer gel was produced. After grinding in a mortar the black powder which was made to decompose this thermally at 350 more degrees C, and was obtained, the powder of light yellow was produced by heat-treating in 2-hour air at 900 degrees C. By powder method X-ray diffraction analysis, it checked that the obtained powder was a perovskite monolayer.

[0016] The result of having investigated the temperature characteristic of the capacity of the thin film capacitor using the above-mentioned compound perovskite oxide powder produced at hardenability resin 5vol% to drawing 11 is shown. Each of PMN<sub>25</sub>, PLZT<sub>24</sub>, and BMT<sub>23</sub> which are a compound perovskite oxide is 70 nF/cm<sup>2</sup>. The above capacity value was shown. PMN<sub>22</sub> of a temperature change with the largest capacity value is [ the temperature characteristic ] the largest, and the rate of change in 25 to 125 degrees C is 3500 ppm/degree C. Considering that the rate of change of a PMN ceramic condenser is several %/degree C, this value is very small. BT<sub>25</sub> and ST<sub>26</sub> which are simple perovskite are 70 nF/cm<sup>2</sup>. Although it was the following capacity consistencies, the capacity rate of change showed the temperature characteristic respectively good in degree C and 200 ppm /or less.

[0017] The description of this example is to have enabled shaping of what was being fabricated in the conventional ceramic sintering method at the temperature of about 1000 times at 150 degrees C, when a dielectric constant fabricates 3000 to 10,000 or more compound perovskite oxide powder 3 using hardenability resin 4. Moreover, by optimizing powder particle size and the addition of hardenability resin 4, the dielectric film 5 which has high capacity and sufficient reinforcement is offered. Although the value of the effective dielectric constant of a dielectric film 5 serves as one half extent of bulk since the dielectric constant of the hardenability resin 4 which binds the compound perovskite oxide powder 3 is as small as 2-4, the temperature characteristic improves with 1 / 10 - 1/100 of bulk substantially.

[0018] By using the above-mentioned thin film capacitor for printed circuit boards, the thin film CR circuit element of high degree of accuracy and high-reliability can be offered. This sectional view and drawing 4 of the top view of a thin film CR circuit element [ in / in drawing 2 / one example of this invention ] and drawing 3 are these circuit diagrams. A thin film CR circuit element is formed the epoxy resin layer 8 for carrying out flattening of the irregularity of the front face of PC board 7 and PC board 7, and on it, and is constituted by the thin film capacitor 40 which consists of the resistance element 9 which consisted of Nichrome alloy film, a PMN dielectric film 10, an up electrode 11, and a lower electrode 30.

[0019] One terminal of a resistance element 9 is connected to an input/output terminal 12, and another terminal is joined to the lower electrode 30 and input/output terminal 13 of a thin film capacitor 40. Moreover, the up electrode 11 of a thin film capacitor 40 is connected to the input/output terminal 14. In addition, the up electrode 11 and input/output terminals 12, 13, and 14 have structure which is two-layer structure, respectively, for example, carried out the laminating of the gold films 11b, 12b, 13b, and 14b to order from the substrate side, respectively on the nickel film 11a, 12a, and 13a and 14a.

[0020] moreover — the time of preparing a wrap protective coat for each component or wiring on a substrate, in order to protect each component, and preparing a protective coat — the up electrode 11 and input/output

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terminals 12, 13, and 14 — it is desirable to make each part express.

[0021] thus, 1 set of resistance elements 9 and the input/output terminal from a thin film capacitor 40 — three pieces — coming out — \*\*\*\* — two of pieces [ them ] — it can take and one resistance element as a resistance element, one thin film capacitor or one resistance element, and the serial component of one thin film capacitor can be chosen in the direction. Furthermore, by allotting the resistance element 9 of two or more groups, and CR component of a thin film capacitor 40, CR circuit element of arbitration is producible. 1 chip 6mmx5mm CR circuit element which the effective area of a thin film capacitor 40 becomes from 1.0mmx1.5mm, four thin film capacitors, and four resistance elements was produced.

[0022] The production approach is explained according to drawing 5 - drawing 9. The spin coat of the epoxy resin was first carried out to the front face of 50mmx50mm PC board 7, it dried at 150 degrees C, and the epoxy resin layer 8 with a thickness of 1 micrometer was formed ( drawing 5 ). This is for making surface irregularity of PC board 7 small, and improving the precision of the dielectric breakdown voltage of a dielectric film, and the resistance of the resistance film, and carried out flattening of the average of roughness height on the front face of a substrate to 0.2 micrometers or less after forming an epoxy resin layer from 0.8 micrometers of the first stage.

[0023] The presentation formed 0.01 micrometers of Nichrome alloy film of nickel/Cr=80/20 with the vacuum deposition method, and the thin line section with a line breadth of 100 micrometers, an input/output terminal 12, the pad section for 13, and the lower electrode 30 section of a thin film capacitor 40 were formed using the photoresist method etc. ( drawing 6 ).

[0024] Production of the PMN dielectric film 10 was performed like the above-mentioned producing method. That is, after applying on a substrate the solvent which made the ultraviolet-rays hardening resin solvent which uses epoxy acrylate as a principal component distribute the PMN powder compounded by the complex polymerization method by the technique of a spin coat etc., resin hardening by desiccation processing and an ultraviolet radiation exposure of a volatile solvent was performed, and etching clearance of the garbage was carried out by the photoresist method ( drawing 7 ).

[0025] The thickness of the formed PMN dielectric film 10 is 5 micrometers, and repeated and produced a spin coat, desiccation, and resin hardening. At the temperature of 80 degrees C, desiccation processing of a volatile solvent is time amount 30 minutes, and UV irradiation is amount of energy 65 KJ/m<sup>2</sup>. The deed temperature rise was suppressed at 150 degrees C or less for time amount 1 minute. The volume fraction of the hardenability resin after resin hardening was 6vol(s)%.

[0026] Next, while carrying out vacuum deposition of the nickel film 11a, 12a, 13a, and 14a and the gold films 11b, 12b, 13b, and 14b one by one, it was processed by the photoresist method, and input/output terminals 12 and 13 and the up electrode 11 were formed. Gold was formed in the front face for improving the wettability of soldering ( drawing 8 ). The overcoat of the epoxy resin was carried out to the last, and \*\*\*\* opium poppy \*\*\*\*\* 21 was formed for the input/output terminal part ( drawing 9 ).

[0027] Thus, as for the capacity of one created capacitor, the 0.010-0.012, and \*\*200 ppm degree C of property of temperature characteristics was acquired 2.7nF\*\*7%, as for dielectric loss tandelta. The resistance of the resistance element of one piece was \*\*25 ppm/degree C in temperature coefficient 10kohm\*\*1%. Since the capacitor element and the resistance element are produced in the thin film process in this invention, the precision of capacity value and resistance is high 10% compared with the conventional chip. Furthermore, generating of the electrical noise by the poor electrical installation between the components which had become a problem conventionally about the component since it was integrating, small and was solvable.

[0028]

[Effect of the Invention] The dielectric film with which a dielectric constant consists of 10,000 or more compound perovskite oxides according to this invention so that clearly from the above example can be produced at the temperature of 150 degrees C or less, and they are 70 nF/cm<sup>2</sup> on a printed circuit board. The thin film capacitor of the above capacity consistency can be offered. Furthermore, the RC circuit component using this thin film capacitor has a high precision of capacity value and resistance 10% or more compared with the conventional chip circuit, and can solve the problem of the electrical noise generated by poor soldering. Moreover, although this invention was characterized by low-temperature formation of a dielectric film and the circuit element using a print resin substrate was offered, it is clear this invention's to have effectiveness also about the component for silicon semiconductor integrated circuits and a GaAs compound semiconductor integrated circuit device.

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**TECHNICAL FIELD**

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[Industrial Application] This invention relates to the thin film capacitor widely used for a public welfare device etc., and its manufacture approach.

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**PRIOR ART**

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[Description of the Prior Art] When forming a thin film capacitor on the printed circuit board made of resin, the cure against heat at the time of the dielectric membrane formation process of having taken into consideration the heat-resistant temperature of a resin substrate is an important technical problem. As a conventional technique, it is SiO<sub>2</sub> by electron cyclotron resonance vapor growth (ECR-CVD method). The approach of forming the thin film capacitor using the film on a glass epoxy group plate with a heat-resistant temperature of 200 degrees C is announced by the 126th page from the 123rd page (1993) of the 5th microelectronics symposium collected works.

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EFFECT OF THE INVENTION

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**TECHNICAL PROBLEM**

[Problem(s) to be Solved by the Invention] SiO<sub>2</sub> formed with the ECR-CVD method The capacity consistencies of a dielectric film capacitor are 13.1 nF/cm<sup>2</sup>. Although the property of practical use level is acquired, considering cost performance, the capacity consistency of 5 times or more is required. In order to attain one 5 times the capacity consistency of this, dielectric thickness had to be set to one fifth of 60nm, and there was a problem on which insulation deteriorates.

[0004] This invention solves said conventional technical problem, and is 70 nF/cm<sup>2</sup>. While aiming at offering the thin film capacitor which has the above capacity consistency and was excellent in insulation, and its manufacture approach, it aims at offering CR circuit element of high degree of accuracy and high-reliability using it.

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**MEANS**

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[Means for Solving the Problem] In order to attain this object, particle size fabricated the compound perovskite oxide powder which is 0.4 micrometers - 1.4 micrometers using 0.5vol(s)% - 7vol% hardenability resin as a dielectric film.

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**OPERATION**

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[Function] The dielectric film which uses as a principal component the compound perovskite oxide with which a dielectric constant has thousands or more and is used for a ceramic condenser by the aforementioned means can be formed at the low temperature of 150 degrees C. Hardenability resin is used in order to bind compound perovskite oxide powder, but since the effective dielectric constant of a dielectric film will fall if the volume fraction of hardenability resin increases, 0.5vol% - 7vol% is the optimal. The particle size of compound perovskite oxide acts on a binding property and electric insulation. In 0.4 micrometers or less, surface area becomes large, and it becomes impossible for particle size to fully bind by 7vol% hardenability resin. Moreover, the opening between the grains with which particle size is set to 1.4 micrometers or more becomes large, and electric insulation deteriorates. Therefore, there is an operation which prevents decline in a dielectric constant and electric insulating degradation by setting particle size to 0.4 micrometers - 1.4 micrometers.

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## EXAMPLE

[Example] Drawing 1 is the sectional view showing the structure of the thin film capacitor in one example of this invention, and a thin film capacitor consists of the dielectric film 5 and the aluminum up electrode 6 which consist of the polycarbonate (it omits Following PC) substrate 1 which is a printed circuit board made of resin, the aluminum lower electrode 2, compound perovskite oxide powder 3, and hardenability resin 4.

[0008] How to manufacture the thin film capacitor of this example is explained. After carrying out cleaning processing of dimension 50mmx50mmx2mm PC board 1, the aluminum film with a thickness of 1 micrometer was formed with vacuum evaporation technique, aluminum was etched by the photoresist method, and the aluminum lower electrode 2 was formed.

[0009] Next,  $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3}\text{O}_3)$  compounded by the complex polymerization method The spin coat of the solvent which made the ultraviolet-rays hardening resin solvent which uses epoxy acrylate as a principal component distribute compound (PMN) perovskite oxide powder was carried out on PC board 1, and resin hardening by desiccation processing and an ultraviolet radiation exposure of a volatile solvent was performed. The dielectric film 5 which carries out etching clearance of the contact part of the aluminum lower electrode 2 by the photoresist method, and consists of compound perovskite oxide powder 3 and hardenability resin 4 was formed.

[0010] The thickness of the formed dielectric film 5 is 5 micrometers, and repeated and produced a spin coat, desiccation, and resin hardening. At the temperature of 80 degrees C, desiccation processing of a volatile solvent is time amount 30 minutes, and UV irradiation is amount of energy 65 KJ/m<sup>2</sup>. The deed temperature rise was suppressed at 150 degrees C or less for time amount 1 minute.

[0011] The volume fraction of the hardenability resin 4 after resin hardening produced the 0.1vol% - 10vol% thing depending on the concentration of the ultraviolet-rays hardening resin material in a solvent. On the dielectric film 5, 1 micrometer of aluminum film was formed with vacuum evaporation technique, it fabricated by the photoresist method, and the aluminum up electrode 6 was formed. The effective area of a thin film capacitor was decided by the part with which the aluminum up electrode 6 and the aluminum lower electrode 2 lapped, and was set to 3mmx2mm by this example.

[0012] A capacity consistency is so large that the capacity consistency of the produced thin film capacitor has a small volume fraction depending on the volume fraction of the hardenability resin 4 in a dielectric film 5. They are 70 nF/cm<sup>2</sup> so that drawing 10 may show. In order to obtain the above capacity consistency, the volume fraction of hardenability resin 4 needs to be less than [ 7vol% ]. However, when the volume fraction became less than [ 0.5vol% ], the binding operation of the PMN powder of hardenability resin 4 became weak, and exfoliation of a dielectric film 5 and decomposition arose.

[0013] Therefore, as for the volume fraction of the hardenability resin 4 in a dielectric film 5, it is desirable that it is 0.5vol(s)% - 7vol%. The particle size of PMN powder also influenced the mechanical strength and dielectric characteristics of a dielectric film 5. Since powdered surface area would increase if particle size is set to 0.4 micrometers or less, by the hardenability resin 4 which is 7vol%, the binding operation was weak, the crack arose in the dielectric film 5 and the short circuit was caused electrically. On the other hand, when the particle size of PMN was set to 1.4 micrometers or more, the irregularity of a dielectric film 5 became large and dielectric breakdown voltage deteriorated remarkably. Therefore, as for the particle size of the compound perovskite oxide powder 3, it is desirable that it is 0.4 micrometers - 1.4 micrometers.

[0014] As a compound perovskite oxide, they are  $\text{TiO}(\text{Ba}_{0.7}\text{Sr}_{0.3})_3$  (BST),  $\text{Ba}(\text{Mg}_{1/3}\text{Ta}_{2/3}\text{O}_3)$  (BMT), and  $\text{BaTiO}_3$  besides PMN (PLZT ( $\text{Zr}(\text{Pb}_{0.9}\text{La}_{0.1})_{0.65}\text{Ti}_{0.35}$ )). (BT) and  $\text{SrTiO}_3$  Similarly (ST) was compounded by the complex polymerization method.

[0015] The synthetic approach of PLZT powder is explained as an example. First, titanium tetra-isopropoxide ( $\text{Ti}_4(\text{C}_3\text{H}_7\text{O})$ ) was dissolved in ethylene glycol / citric-acid solution, and then a zirconium nitrate ( $\text{Zr}(\text{NO}_3)_2$  and  $\text{H}_2\text{O}$ ), lead acetate ( $\text{Pb}(\text{CH}_3\text{COO})_2$  and  $3\text{H}_2\text{O}$ ), and an acetic-acid lanthanum ( $\text{La}(\text{CH}_3\text{COO})_3$  and  $1.5\text{H}_2\text{O}$ ) were dissolved. Heating concentration of this solution was carried out, the polyesterification reaction was advanced, and polymer gel was produced. After grinding in a mortar the black powder which was made to decompose this thermally at 350 more degrees C, and was obtained, the powder of light yellow was produced by heat-treating in 2-hour air at 900 degrees C. By powder method X-ray diffraction analysis, it checked that the obtained powder was a perovskite monolayer.

[0016] The result of having investigated the temperature characteristic of the capacity of the thin film capacitor using the above-mentioned compound perovskite oxide powder produced at hardenability resin 5vol% to drawing 11 is shown. Each of PMN25, PLZT24, and BMT23 which are a compound perovskite oxide is 70 nF/cm<sup>2</sup>. The above

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capacity value was shown. PMN22 of a temperature change with the largest capacity value is [ the temperature characteristic ] the largest, and the rate of change in 25 to 125 degrees C is 3500 ppm/degree C. Considering that the rate of change of a PMN ceramic condenser is several %/degree C, this value is very small. BT25 and ST26 which are simple perovskite are 70 nF/cm<sup>2</sup>. Although it was the following capacity consistencies, the capacity rate of change showed the temperature characteristic respectively good in degree C and 200 ppm /or less.

[0017] The description of this example is to have enabled shaping of what was being fabricated in the conventional ceramic sintering method at the temperature of about 1000 times at 150 degrees C, when a dielectric constant fabricates 3000 to 10,000 or more compound perovskite oxide powder 3 using hardenability resin 4. Moreover, by optimizing powder particle size and the addition of hardenability resin 4, the dielectric film 5 which has high capacity and sufficient reinforcement is offered. Although the value of the effective dielectric constant of a dielectric film 5 serves as one half extent of bulk since the dielectric constant of the hardenability resin 4 which binds the compound perovskite oxide powder 3 is as small as 2-4, the temperature characteristic improves with 1 / 10 - 1/100 of bulk substantially.

[0018] By using the above-mentioned thin film capacitor for printed circuit boards, the thin film CR circuit element of high degree of accuracy and high-reliability can be offered. This sectional view and drawing 4 of the top view of a thin film CR circuit element [ in / in drawing 2 / one example of this invention ] and drawing 3 are these circuit diagrams. A thin film CR circuit element is formed the epoxy resin layer 8 for carrying out flattening of the irregularity of the front face of PC board 7 and PC board 7, and on it, and is constituted by the thin film capacitor 40 which consists of the resistance element 9 which consisted of Nichrome alloy film, a PMN dielectric film 10, an up electrode 11, and a lower electrode 30.

[0019] One terminal of a resistance element 9 is connected to an input/output terminal 12, and another terminal is joined to the lower electrode 30 and input/output terminal 13 of a thin film capacitor 40. Moreover, the up electrode 11 of a thin film capacitor 40 is connected to the input/output terminal 14. In addition, the up electrode 11 and input/output terminals 12, 13, and 14 have structure which is two-layer structure, respectively, for example, carried out the laminating of the gold films 11b, 12b, 13b, and 14b to order from the substrate side, respectively on the nickel film 11a, 12a, and 13a and 14a.

[0020] moreover — the time of preparing a wrap protective coat for each component or wiring on a substrate, in order to protect each component, and preparing a protective coat — the up electrode 11 and input/output terminals 12, 13, and 14 — it is desirable to make each part express.

[0021] thus, 1 set of resistance elements 9 and the input/output terminal from a thin film capacitor 40 — three pieces — coming out — \*\*\*\* — two of pieces [ them ] — it can take and one resistance element as a resistance element, one thin film capacitor or one resistance element, and the serial component of one thin film capacitor can be chosen in the direction. Furthermore, by allotting the resistance element 9 of two or more groups, and CR component of a thin film capacitor 40, CR circuit element of arbitration is producible. 1 chip 6mmx5mm CR circuit element which the effective area of a thin film capacitor 40 becomes from 1.0mmx1.5mm, four thin film capacitors, and four resistance elements was produced.

[0022] The production approach is explained according to drawing 5 - drawing 9. The spin coat of the epoxy resin was first carried out to the front face of 50mmx50mm PC board 7, it dried at 150 degrees C, and the epoxy resin layer 8 with a thickness of 1 micrometer was formed ( drawing 5 ). This is for making surface irregularity of PC board 7 small, and improving the precision of the dielectric breakdown voltage of a dielectric film, and the resistance of the resistance film, and carried out flattening of the average of roughness height on the front face of a substrate to 0.2 micrometers or less after forming an epoxy resin layer from 0.8 micrometers of the first stage.

[0023] The presentation formed 0.01 micrometers of Nichrome alloy film of nickel/Cr=80/20 with the vacuum deposition method, and the thin line section with a line breadth of 100 micrometers, an input/output terminal 12, the pad section for 13, and the lower electrode 30 section of a thin film capacitor 40 were formed using the photoresist method etc. ( drawing 6 ).

[0024] Production of the PMN dielectric film 10 was performed like the above-mentioned producing method. That is, after applying on a substrate the solvent which made the ultraviolet-rays hardening resin solvent which uses epoxy acrylate as a principal component distribute the PMN powder compounded by the complex polymerization method by the technique of a spin coat etc., resin hardening by desiccation processing and an ultraviolet radiation exposure of a volatile solvent was performed, and etching clearance of the garbage was carried out by the photoresist method ( drawing 7 ).

[0025] The thickness of the formed PMN dielectric film 10 is 5 micrometers, and repeated and produced a spin coat, desiccation, and resin hardening. At the temperature of 80 degrees C, desiccation processing of a volatile solvent is time amount 30 minutes, and UV irradiation is amount of energy 65 KJ/m<sup>2</sup>. The deed temperature rise was suppressed at 150 degrees C or less for time amount 1 minute. The volume fraction of the hardenability resin after resin hardening was 6vol(s)%.

[0026] Next, while carrying out vacuum deposition of the nickel film 11a, 12a, 13a, and 14a and the gold films 11b, 12b, 13b, and 14b one by one, it was processed by the photoresist method, and input/output terminals 12 and 13 and the up electrode 11 were formed. Gold was formed in the front face for improving the wettability of soldering ( drawing 8 ). The overcoat of the epoxy resin was carried out to the last, and \*\*\*\* opium poppy \*\*\*\*\* 21 was formed for the input/output terminal part ( drawing 9 ).

[0027] Thus, as for the capacity of one created capacitor, the 0.010-0.012, and \*\*200 ppm degree C of property of temperature characteristics was acquired 2.7nF\*\*7%, as for dielectric loss tandelta. The resistance of the resistance

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element of one piece was  $\pm 25$  ppm/degree C in temperature coefficient  $10\text{kohm} \pm 1\%$ . Since the capacitor element and the resistance element are produced in the thin film process in this invention, the precision of capacity value and resistance is high 10% compared with the conventional chip. Furthermore, generating of the electrical noise by the poor electrical installation between the components which had become a problem conventionally about the component since it was integrating, small and was solvable.

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**DESCRIPTION OF DRAWINGS**

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**[Brief Description of the Drawings]**

- [Drawing 1]** The sectional view showing the structure of the thin film capacitor in one example of this invention
- [Drawing 2]** The top view of CR circuit element in one example of this invention
- [Drawing 3]** The sectional view of CR circuit element in one example of this invention
- [Drawing 4]** The circuit diagram of CR circuit element in one example of this invention
- [Drawing 5]** Drawing showing the manufacture approach of CR circuit element in one example of this invention
- [Drawing 6]** Drawing showing the manufacture approach of CR circuit element in one example of this invention
- [Drawing 7]** Drawing showing the manufacture approach of CR circuit element in one example of this invention
- [Drawing 8]** Drawing showing the manufacture approach of CR circuit element in one example of this invention
- [Drawing 9]** Drawing showing the manufacture approach of CR circuit element in one example of this invention
- [Drawing 10]** Drawing showing the relation between the capacity consistency of a thin film capacitor, and the volume fraction of hardenability resin
- [Drawing 11]** Drawing showing the temperature characteristic of a thin film capacitor

**[Description of Notations]**

- 1 Seven PC board
- 2 Aluminum Lower Electrode
- 3 Compound Perovskite Oxide Powder
- 4 Hardenability Resin
- 5 Dielectric Film
- 6 Aluminum Up Electrode
- 8 Epoxy Resin Layer
- 9 Resistance Element
- 10 PMN Dielectric Film
- 11 Up Electrode
- 12, 13, 14 Input/output terminal

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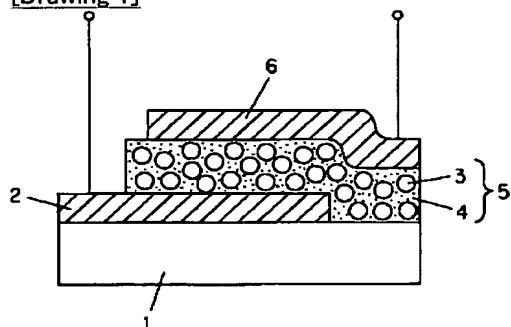
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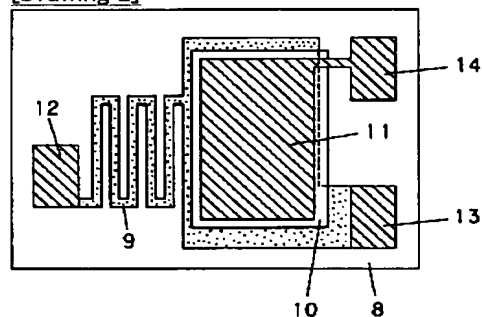
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## DRAWINGS

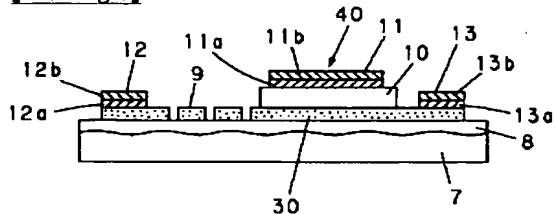
[Drawing 1]



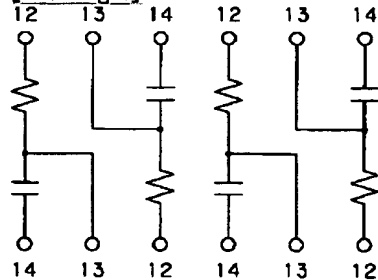
[Drawing 2]



[Drawing 3]



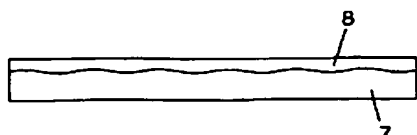
[Drawing 4]



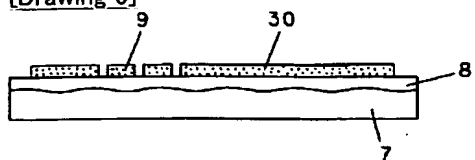
[Drawing 5]

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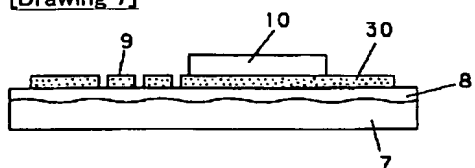




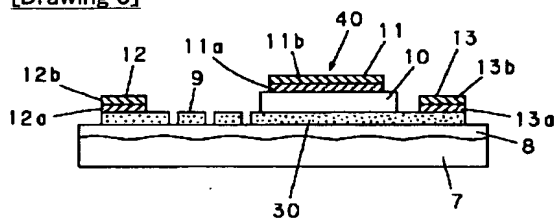
[Drawing 6]



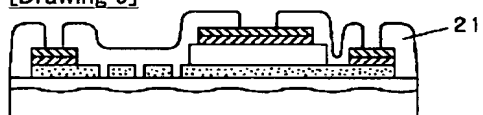
[Drawing 7]



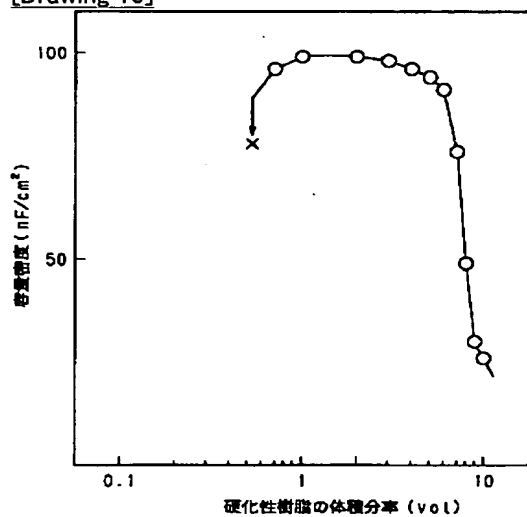
[Drawing 8]



[Drawing 9]

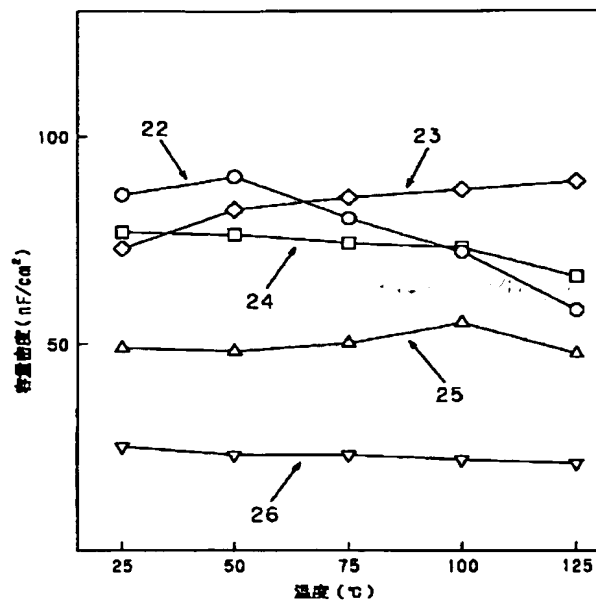


[Drawing 10]



[Drawing 11]

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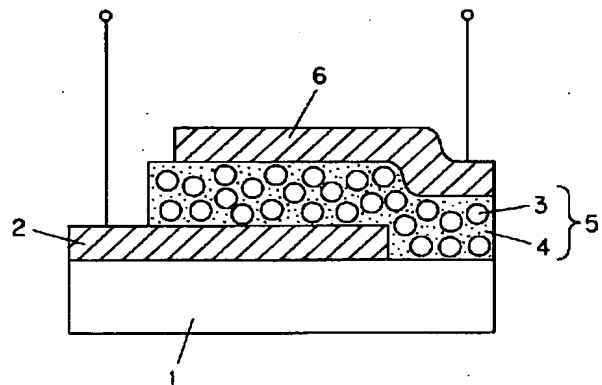
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(54)【発明の名称】 薄膜コンデンサ及びその製造方法

(57)【要約】

【目的】 150℃以下の温度で作製でき、70nF/cm<sup>2</sup>以上の容量密度を有し、かつ、絶縁性に優れた薄膜コンデンサ及びその製造方法とともに、それを用いた高精度・高信頼性のCR回路素子を提供することを目的としている。

【構成】 薄膜コンデンサは樹脂製プリント基板であるPC(ポリカーボネイト)基板1、アルミ下部電極2、複合ペロブスカイト酸化物粉末3と硬化性樹脂4から構成される誘電体膜5、及びアルミ上部電極6からなる。誘電率が数千以上の複合ペロブスカイト酸化物粉末3を硬化性樹脂4を含有する揮発性溶媒に分散させてスピコート法でPC基板3上に塗布した後、80℃で揮発溶媒の乾燥除去、紫外光照射によって樹脂硬化することにより、150℃以下で誘電体膜5を形成する。



## 【特許請求の範囲】

【請求項 1】 下部電極と上部電極との間に誘電体膜を設けた薄膜コンデンサであって、誘電体膜として複合ペロブスカイト酸化物と硬化性樹脂の混合体を用いたことを特徴する薄膜コンデンサ。

【請求項 2】 複合ペロブスカイト酸化物を粉末とし、その粉末の粒径が  $0.4\mu\text{m} \sim 1.4\mu\text{m}$  であることを特徴とする請求項 1 記載の薄膜コンデンサ。

【請求項 3】 複合ペロブスカイト酸化物を粉末とし、その粉末への硬化性樹脂の添加量が  $0.5\text{vol}\% \sim 7\text{vol}\%$  であることを特徴とする請求項 1 記載の薄膜コンデンサ。

【請求項 4】 硬化性樹脂として紫外線硬化樹脂を用いたことを特徴とする請求項 1 記載の薄膜コンデンサ。

【請求項 5】 複合ペロブスカイト酸化物の主成分が、組成式が  $\text{ABO}_3$  で表され A として  $\text{Pb}$ ,  $\text{Sr}$ ,  $\text{Ba}$ ,  $\text{La}$  の少なくとも 1 種を含有し、B として  $\text{Ti}$ ,  $\text{Zr}$ ,  $\text{Ta}$ ,  $\text{Mg}$ ,  $\text{Nb}$  の少なくとも 1 種を含有することを特徴とする請求項 1 記載の薄膜コンデンサ。

【請求項 6】 基板上に下部電極を形成し、前記下部電極上に複合ペロブスカイト酸化物粉末と硬化性樹脂の混合体を設けてその後  $150^\circ\text{C}$  以下の温度で前記硬化樹脂を硬化させて誘電体膜を形成し、前記誘電体膜の上に上部電極を形成したことを特徴とする薄膜コンデンサの製造方法。

【請求項 7】 硬化性樹脂を紫外線硬化樹脂とし、紫外線を照射して誘電体膜を形成することを特徴とする請求項 6 記載の薄膜コンデンサの製造方法。

【請求項 8】 抵抗とコンデンサを電気的に結合した CR 回路素子であって、コンデンサとして請求項 1 記載の薄膜コンデンサを用いたことを特徴とする CR 回路素子。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】 本発明は民生機器等に広く用いられる薄膜コンデンサ及びその製造方法に関するものである。

## 【0002】

【従来の技術】 樹脂製プリント基板上に薄膜コンデンサを形成する場合、樹脂基板の耐熱温度を考慮した誘電体成膜プロセス時の熱対策は重要な技術課題である。従来技術としては、電子サイクロトロン共鳴気相成長法 (ECR-CVD 法) によって  $\text{SiO}_2$  膜を用いた薄膜コンデンサを耐熱温度  $200^\circ\text{C}$  のガラスエポキシ基板上に形成する方法が、第 5 回マイクロエレクトロニクスシンポジウム論文集 (1993 年) 第 123 ページから第 126 ページに発表されている。

## 【0003】

【発明が解決しようとする課題】 ECR-CVD 法で形成された  $\text{SiO}_2$  誘電体膜コンデンサの容量密度は  $13.1\text{nF}/\text{cm}^2$  と実用レベルの特性が得られている

が、コストパフォーマンスを考えると 5 倍以上の容量密度が要求される。5 倍の容量密度を達成するためには誘電体膜厚を  $1/5$  の  $60\text{nm}$  にしなければならず、絶縁性が劣化する問題があった。

【0004】 本発明は前記従来の課題を解決するもので、 $70\text{nF}/\text{cm}^2$  以上の容量密度を有し、かつ、絶縁性に優れた薄膜コンデンサ及びその製造方法を提供することを目的とするとともに、それを用いた高精度・高信頼性の CR 回路素子を提供することを目的としている。

## 【0005】

【課題を解決するための手段】 この目的を達成するために、誘電体膜として粒径が  $0.4\mu\text{m} \sim 1.4\mu\text{m}$  の複合ペロブスカイト酸化物粉末を  $0.5\text{vol}\% \sim 7\text{vol}\%$  の硬化性樹脂を用いて成形した。

## 【0006】

【作用】 前記の手段により、誘電率が数千以上を有しセラミックコンデンサに用いられる複合ペロブスカイト酸化物を主成分とする誘電体膜を  $150^\circ\text{C}$  の低温度で形成することができる。硬化性樹脂は複合ペロブスカイト酸化物粉末をバインディングするために用いられるが、硬化性樹脂の体積分率が多くなると誘電体膜の実効誘電率が低下してしまうので、 $0.5\text{vol}\% \sim 7\text{vol}\%$  が最適である。複合ペロブスカイト酸化物の粒径はバインディング特性と電気的絶縁性に作用する。粒径が  $0.4\mu\text{m}$  以下では表面積が大きくなり、 $7\text{vol}\%$  の硬化性樹脂では十分にバインディングできなくなる。また、粒径が  $1.4\mu\text{m}$  以上になると粒間の空隙が大きくなり電気的絶縁性が劣化する。従って、粒径を  $0.4\mu\text{m} \sim 1.4\mu\text{m}$  とすることによって誘電率の低下と電気的絶縁性の劣化を防ぐ作用がある。

## 【0007】

【実施例】 図 1 は本発明の一実施例における薄膜コンデンサの構造を示す断面図で、薄膜コンデンサは樹脂製プリント基板であるポリカーボネイト (以下 PC と略す) 基板 1、アルミ下部電極 2、複合ペロブスカイト酸化物粉末 3 と硬化性樹脂 4 からなる誘電体膜 5、アルミ上部電極 6 からなる。

【0008】 本実施例の薄膜コンデンサを製造する方法について説明する。寸法  $50\text{mm} \times 50\text{mm} \times 2\text{mm}$  の PC 基板 1 を脱脂処理した後、厚さ  $1\mu\text{m}$  のアルミ膜を真空蒸着法で成膜し、フォトレジスト法でアルミをエッチングしてアルミ下部電極 2 を形成した。

【0009】 次に鋳体重合法で合成した  $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3$  (PMN) 複合ペロブスカイト酸化物粉末をエポキシアクリレート主成分とする紫外線硬化樹脂溶媒に分散させた溶剤を PC 基板 1 上にスピンコートし、揮発性溶媒の乾燥処理と紫外光照射による樹脂硬化を行った。フォトレジスト法でアルミ下部電極 2 のコンタクト部分をエッチング除去して複合ペロブスカイト酸

化物粉末3と硬化性樹脂4からなる誘電体膜5を形成した。

【0010】その形成した誘電体膜5の膜厚は5 $\mu$ mで、スピンコート、乾燥、樹脂硬化を繰り返して作製した。揮発性溶媒の乾燥処理は温度80℃で時間30分、紫外線照射はエネルギー量65KJ/m<sup>2</sup>で時間1分行い温度上昇は150℃以下に抑えた。

【0011】樹脂硬化後の硬化性樹脂4の体積分率は溶剤中の紫外線硬化樹脂材の濃度に依存し、0.1vol%~10vol%のものを作製した。誘電体膜5上にアルミ膜を真空蒸着法で1 $\mu$ m成膜し、フォトリソ法で成形してアルミ上部電極6を形成した。薄膜コンデンサの実効面積はアルミ上部電極6とアルミ下部電極2が重なった部分で決まり、本実施例では3mm×2mmとした。

【0012】作製した薄膜コンデンサの容量密度は誘電体膜5中の硬化性樹脂4の体積分率に依存し、体積分率が小さいほど容量密度は大きい。図10からわかるように70nF/cm<sup>2</sup>以上の容量密度を得るためには硬化性樹脂4の体積分率は7vol%以下であることが必要である。しかし、体積分率が0.5vol%以下になると硬化性樹脂4のPMN粉末のバインディング作用が弱くなり、誘電体膜5の剥離、分解が生じた。

【0013】従って、誘電体膜5中の硬化性樹脂4の体積分率は0.5vol%~7vol%であることが望ましい。PMN粉末の粒径も誘電体膜5の機械的強度と誘電特性に影響した。粒径が0.4 $\mu$ m以下になると粉末の表面積が増大するため7vol%の硬化性樹脂4ではバインディング作用が弱く、誘電体膜5にクラックが生じて電気的に短絡を起こした。一方、PMNの粒径が1.4 $\mu$ m以上になると誘電体膜5の凹凸が大きくなり絶縁破壊電圧が著しく劣化した。従って、複合ペロブスカイト酸化物粉末3の粒径は0.4 $\mu$ m~1.4 $\mu$ mであることが望ましい。

【0014】複合ペロブスカイト酸化物としてはPMNの他に(Pb<sub>0.9</sub>La<sub>0.1</sub>)(Zr<sub>0.65</sub>Ti<sub>0.35</sub>)(PLZT)、(Ba<sub>0.7</sub>Sr<sub>0.3</sub>)TiO<sub>3</sub>(BST)、Ba(Mg<sub>1/3</sub>Ta<sub>2/3</sub>)O<sub>3</sub>(BMT)、BaTiO<sub>3</sub>(BT)、SrTiO<sub>3</sub>(ST)を同じく錯体重合法によって合成した。

【0015】例として、PLZT粉末の合成方法を説明する。まず、チタニウムテトライソプロポキシド(Ti(C<sub>3</sub>H<sub>7</sub>O)<sub>4</sub>)をエチレングリコール/クエン酸溶液に溶解させ、次に硝酸ジルコニウム(Zr(NO<sub>3</sub>)<sub>2</sub>·H<sub>2</sub>O)、酢酸鉛(Pb(CH<sub>3</sub>COO)<sub>2</sub>·3H<sub>2</sub>O)、酢酸ランタン(La(CH<sub>3</sub>COO)<sub>3</sub>·1.5H<sub>2</sub>O)を溶解させた。この溶液を加熱濃縮し、ポリエステル化反応を進行させて高分子ゲルを作製した。これをさらに350℃で加熱分解させて得られた黒色の粉末を乳鉢中で粉碎した後、900℃で2時間空气中で熟

処理することにより淡黄色の粉末を作製した。粉末法X線回折分析により、得られた粉末がペロブスカイト単層であることを確認した。

【0016】図11に硬化性樹脂5vol%で作製した上記の複合ペロブスカイト酸化物粉末を用いた薄膜コンデンサの容量の温度特性を調べた結果を示す。複合ペロブスカイト酸化物であるPMN25、PLZT24、BMT23はいずれも70nF/cm<sup>2</sup>以上の容量値を示した。温度特性は容量値が一番大きいPMN22が最も温度変化が大きく、25℃から125℃での変化率は3500ppm/℃である。この値はPMNセラミックコンデンサの変化率が数%/℃であることを考えると極めて小さい。単純ペロブスカイトであるBT25、ST26は70nF/cm<sup>2</sup>以下の容量密度であるが、その容量変化率はそれぞれ200ppm/℃以下と良好な温度特性を示した。

【0017】本実施例の特徴は誘電率が3千から1万以上の複合ペロブスカイト酸化物粉末3を硬化性樹脂4を用いて成形することにより、従来のセラミック焼結法では千度近い温度で成形していたものを、150℃で成形可能にしたことにある。また粉末粒径と硬化性樹脂4の添加量を最適化することによって、高容量かつ十分な強度を有する誘電体膜5を提供するものである。複合ペロブスカイト酸化物粉末3をバインディングする硬化性樹脂4の誘電率は2~4と小さいので誘電体膜5の実効誘電率の値はバルクの半分程度となるが、温度特性はバルクの1/10~1/100と大幅に改善される。

【0018】上記プリント基板用薄膜コンデンサを用いることで、高精度かつ高信頼性の薄膜CR回路素子を提供することができる。図2は本発明の一実施例における薄膜CR回路素子の平面図、図3は同断面図、図4は同回路図である。薄膜CR回路素子はPC基板7、PC基板7の表面の凹凸を平坦化するためのエポキシ樹脂層8、その上に形成され、ニクロム合金膜で構成された抵抗素子9、PMN誘電体膜10、上部電極11、下部電極30より構成される薄膜コンデンサ40によって構成される。

【0019】抵抗素子9の一方の端子は入出力端子12へ接続され、もう一方の端子は薄膜コンデンサ40の下部電極30及び入出力端子13に接合される。また薄膜コンデンサ40の上部電極11は入出力端子14へ接続されている。なお、上部電極11及び入出力端子12、13、14はそれぞれ2層構造となっており、例えば基板側からニッケル膜11a、12a、13a、14a上にそれぞれ金膜11b、12b、13b、14bを順に積層した構造となっている。

【0020】また各素子を保護するために各素子や配線を覆う保護膜を基板上に設けてもよく、保護膜を設ける際には、上部電極11及び入出力端子12、13、14それぞれの一部を表出させることが好ましい。

【0021】このように1組の抵抗素子9と薄膜コンデンサ40からは入出力端子が3個でており、そのうちの2個の取り方で抵抗素子としての抵抗素子1個、薄膜コンデンサ1個、あるいは抵抗素子1個と薄膜コンデンサ1個の直列素子を選ぶことができる。更に複数の組の抵抗素子9と薄膜コンデンサ40のCR素子を配することにより、任意のCR回路素子を作製することができる。薄膜コンデンサ40の実効面積が1.0mm×1.5mm、薄膜コンデンサ4個、抵抗素子4個からなる1チップ6mm×5mmのCR回路素子を作製した。

【0022】図5～図9に従って作製方法を説明する。まず50mm×50mmのPC基板7の表面にエポキシ樹脂をスピンコートして150℃で乾燥し、厚さ1μmのエポキシ樹脂層8を形成した(図5)。これはPC基板7の表面凹凸を小さくして誘電体膜の絶縁破壊電圧と抵抗膜の抵抗値の精度を改善するためであり、基板表面の平均粗さを初期の0.8μmからエポキシ樹脂層を形成後0.2μm以下へと平坦化した。

【0023】真空蒸着法で組成がNi/Cr=80/20のニクロム合金膜を0.01μm成膜し、フォトレジスト法等を用いて線幅100μmの細線部、入出力端子12、13用のパッド部、薄膜コンデンサ40の下部電極30部を形成した(図6)。

【0024】PMN誘電体膜10の作製は前述の作製法と同様に行った。即ち、錯体重合法で合成したPMN粉末をエポキシアクリレートを主成分とする紫外線硬化樹脂溶媒に分散させた溶剤をスピンコート等の手法によって基板上に塗布した後に揮発性溶媒の乾燥処理と紫外光照射による樹脂硬化を行い、フォトレジスト法で不要部分をエッチング除去した(図7)。

【0025】形成したPMN誘電体膜10の膜厚は5μmで、スピンコート、乾燥、樹脂硬化を繰り返して作製した。揮発性溶媒の乾燥処理は温度80℃で時間30分、紫外線照射はエネルギー量65KJ/m<sup>2</sup>で時間1分行い温度上昇は150℃以下に抑えた。樹脂硬化後の硬化性樹脂の体積分率は6vol%であった。

【0026】次にニッケル膜11a、12a、13a、14aと金膜11b、12b、13b、14bを順次真空蒸着するとともにフォトレジスト法により加工して、入出力端子12、13及び上部電極11を形成した。表面に金を形成したのは半田付けの濡れ性をよくするためである(図8)。最後にエポキシ樹脂をオーバーコートし、入出力端子部分を窓開けして保護膜21を形成した(図9)。

【0027】このように作成されたコンデンサ1個の容量は2.7nF±7%、誘電損失tanδは0.010～0.012、温度特性±200ppm/℃の特性が得られた。抵抗素子は1個の抵抗値が10kΩ±1%、温度係数±25ppm/℃であった。本発明では薄膜プロセスでコンデンサ素子と抵抗素子を作製しているので容量

値と抵抗値の精度が従来のチップ部品に比べて10%高い。更に素子を小型・集積化しているために従来問題になっていた素子間の電氣的接続不良による電氣的ノイズの発生を解決できた。

【0028】

【発明の効果】以上の実施例から明らかなように、本発明によれば誘電率が1万以上の複合ペロブスカイト酸化物からなる誘電体膜を150℃以下の温度で作製することができ、プリント基板上に70nF/cm<sup>2</sup>以上の容量密度の薄膜コンデンサを提供することができる。更にこの薄膜コンデンサを用いたRC回路素子は従来のチップ部品回路に比べて容量値と抵抗値の精度が10%以上高く、半田付け不良などによって発生していた電氣的ノイズの問題を解決することができる。また、本発明は誘電体膜の低温形成を特徴としてプリント樹脂基板を用いた回路素子を提供したが、本発明はシリコン半導体集積回路用素子、GaAs化合物半導体集積回路素子についても効果を有することは明らかである。

【図面の簡単な説明】

【図1】本発明の一実施例における薄膜コンデンサの構造を示す断面図

【図2】本発明の一実施例におけるCR回路素子の平面図

【図3】本発明の一実施例におけるCR回路素子の断面図

【図4】本発明の一実施例におけるCR回路素子の回路図

【図5】本発明の一実施例におけるCR回路素子の製造方法を示す図

【図6】本発明の一実施例におけるCR回路素子の製造方法を示す図

【図7】本発明の一実施例におけるCR回路素子の製造方法を示す図

【図8】本発明の一実施例におけるCR回路素子の製造方法を示す図

【図9】本発明の一実施例におけるCR回路素子の製造方法を示す図

【図10】薄膜コンデンサの容量密度と硬化性樹脂の体積分率との関係を示す図

【図11】薄膜コンデンサの温度特性を示す図

【符号の説明】

1、7 PC基板

2 アルミ下部電極

3 複合ペロブスカイト酸化物粉末

4 硬化性樹脂

5 誘電体膜

6 アルミ上部電極

8 エポキシ樹脂層

9 抵抗素子

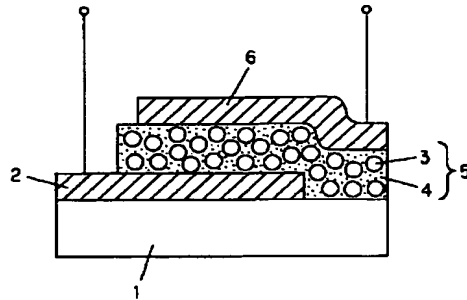
10 PMN誘電体膜



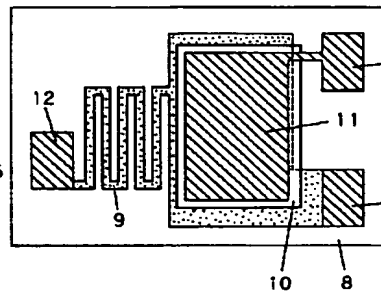
11 上部電極

12, 13, 14 入出力端子

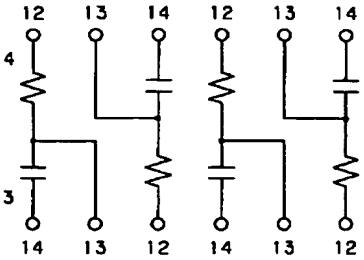
【図1】



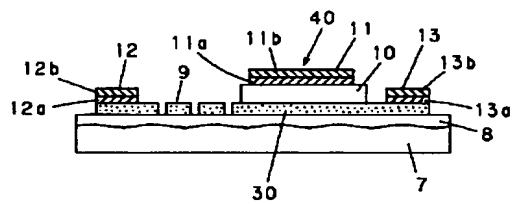
【図2】



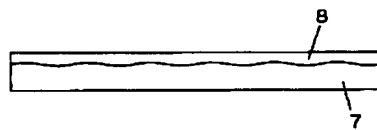
【図4】



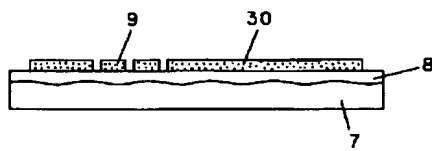
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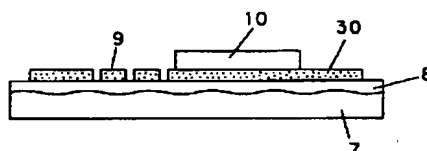
【図5】



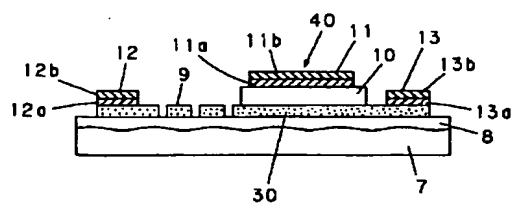
【図6】



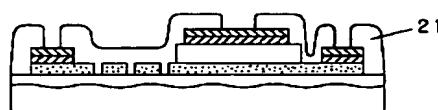
【図7】



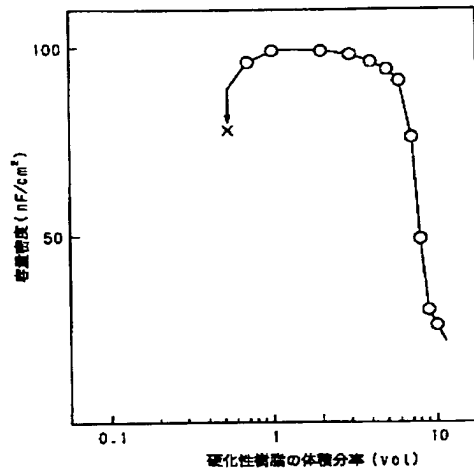
【図8】



【図9】



【図10】



【図11】

